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(REV 11-98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

MEIC:070

U.S. APPLICATION NO. (If known, see 37 CFR 1.51)

09/423806

INTERNATIONAL APPLICATION NO.  
PCT/JP99/01179INTERNATIONAL FILING DATE  
March 11, 1999PRIORITY DATE CLAIMED  
March 13, 1998

## TITLE OF INVENTION

COMPOSITE COMPONENT AND METHOD OF MANUFACTURING THE SAME

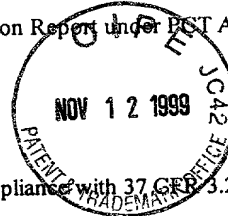
APPLICANT(S) FOR DO/EO/US Akihiko IBATA, Takaishi-shi, Japan; Michio Ooba, Kadoma-shi, Japan; Toshihiro YOSHIZAWA, Higashiosaka-shi, Japan

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

## Items 11. to 16. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A **FIRST** preliminary amendment.  
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:  
Forms PCT/IB/301; PCT/IB/304; and PCT/IB/308



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AUTHORIZATION TO DEBIT  
OR CREDIT FEES TO  
DEP. ACCT. 16-0331  
PARKHURST & WENDEL

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)

097423806

INTERNATIONAL APPLICATION NO.  
PCT/JP99/01179

ATTORNEY'S DOCKET NUMBER  
MEIC:070

17. ☒ The following fees are submitted:

**BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :**

- Neither international preliminary examination fee (37 CFR 1.482)  
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO  
and International Search Report not prepared by the EPO or JPO ..... \$970.00
- International preliminary examination fee (37 CFR 1.482) not paid to  
USPTO but International Search Report prepared by the EPO or JPO ..... \$840.00
- International preliminary examination fee (37 CFR 1.482) not paid to USPTO but  
international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... \$760.00
- International preliminary examination fee paid to USPTO (37 CFR 1.482)  
but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... \$670.00
- International preliminary examination fee paid to USPTO (37 CFR 1.482)  
and all claims satisfied provisions of PCT Article 33(1)-(4) ..... \$96.00

**ENTER APPROPRIATE BASIC FEE AMOUNT =**

**CALCULATIONS PTO USE ONLY**

\$ 840.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30  
months from the earliest claimed priority date (37 CFR 1.492(e)).

\$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	19 - 20 =	0	X \$18.00
Independent claims	5 - 3 =	2	X \$78.00

\$

\$ 156.00

MULTIPLE DEPENDENT CLAIM(S) (if applicable) + \$260.00

\$

**TOTAL OF ABOVE CALCULATIONS = \$ 996.00**

Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement  
must also be filed (Note 37 CFR 1.9, 1.27, 1.28).

\$

**SUBTOTAL = \$ 996.00**

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30  
months from the earliest claimed priority date (37 CFR 1.492(f)).

\$

**TOTAL NATIONAL FEE = \$ 996.00**

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be  
accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +

\$

**TOTAL FEES ENCLOSED = \$ 996.00**

Amount to be:  
refunded \$  
charged \$

- a. ☒ A check in the amount of \$ 996.00 to cover the above fees is enclosed.
- b. ☐ Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_ to cover the above fees.  
A duplicate copy of this sheet is enclosed.
- c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any  
overpayment to Deposit Account No. 16-0331. A duplicate copy of this sheet is enclosed.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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NAME  
25,177

REGISTRATION NUMBER

ATTY. DOCKET NO.: MEIC:070

## COMPOSITE COMPONENT AND METHOD OF MANUFACTURING THE SAME

## FIELD OF THE INVENTION

The present invention relates to a composite component  
5 used for a variety of electronic devices and communication  
equipment. The invention also relates to a method of  
manufacturing the composite component.

## BACKGROUND OF THE INVENTION

10 A variety of composite components including coils,  
capacitors, resistors, and like components are used widely for  
various electronic devices and communication equipment.  
Recently demand for miniaturized and thin composite components  
has risen. Additionally noise reduction functions of  
15 composite components have become more important for electronic  
devices which operate at higher frequencies and are digital.

There have been L/C composite components constructed by  
stacking a laminated coil and a laminated ceramic capacitor,  
such as those disclosed in Japanese Patent Examined  
20 Publications, Nos. S59-24534, and S62-28891, which are some  
examples of small size composite components of the prior art  
which have a noise reduction function. Furthermore, a variety  
of structures for L/C composite components have been disclosed  
in Japanese Patent Examined Publication, No. S62-28891,  
25 Japanese Patent Laid-open Publication, No. H01-192107, and so  
on, each teaching a variation in a three-dimensional  
arrangement of a coil and a capacitor.

Generally a composite component for noise reduction  
contains a filter circuit of L-type, T-type,  $\pi$ -type, or the  
30 like, comprising a combination of a plurality of coils and a  
plurality of capacitors. However, structures of laminated L/C  
composite components of the prior art have been such that they  
are capable of composing a filter circuit of only one type of

the above circuits. A L/C composite component disclosed in Japanese Patent Examined Publication, No. S62-28891, for instance, has such structure that it can compose only a T-type filter.

5        Moreover, the conventional composite components had such problems with interference among coils constructed therein, and poor compatibility between coil material and capacitor material in a process of sintering. That is, there are differences in physical properties such as coefficient of  
10 thermal expansion, sintering characteristic, and so on, between magnetic material used for increasing a characteristic of the coils and the dielectric material constituting the capacitors. As a result, a defect such as a delamination, warpage, and the like often occurred during sintering process  
15 of the laminated composite components.

Since a priority has usually been placed for ensuring the compatibility between magnetic material and dielectric material in order to avoid the above-referred defects, neither material has been able to function effectively to the maximum  
20 extent of their properties. Also, there has been a limit in miniaturizing the conventional L/C composite components, since they are composed of laminated coils and laminated ceramic capacitors by stacking them one against another.

On the other hand, an L/C composite component of another  
25 type of structure has been suggested, in which a coated copper wire is wound around a laminated chip capacitor. However, this structure has a problem that it reduces yields in production of composite components, since it results in a large dispersion in characteristics of coils. Moreover, this  
30 structure has a difficulty in making connections between ends of the copper wire of the coil and terminals of the laminated

chip capacitor, thereby making it difficult to miniaturize the L/C composite component or to form the L/C composite component into a chip component.

5 An object of the present invention is to provide a composite component having a new structure, which eliminates the above-described drawbacks of the conventional composite components, and a method of manufacturing the composite component.

10 Another object of the invention is to provide a composite component having a structure, which is so designed that the composite component containing various kinds of filter circuits can be manufactured easily and effectively with increased productivity and without making a substantial change in the manufacturing condition, and a method of  
15 manufacturing the composite component.

#### SUMMARY OF THE INVENTION

A composite component of the present invention comprises

20 (1) a capacitor composed of at least one insulation layer and at least two electrode layers ; and

(2) a spiral strip of conductor and a plurality of terminals formed in close contact to an external peripheral surface of the capacitor or an external peripheral surface of a portion of the insulation layer not serving for the  
25 capacitor, wherein the electrode layers and the spiral strip of conductor are electrically connected to the plurality of terminals.

Another composite component of the present invention comprises

30 (1) a spiral strip of conductor formed in close contact to an insulation body or a magnetic body, and

(2) a capacitor composed of at least one insulation layer and at least two electrode layers, wherein the spiral strip of conductor and the capacitor are laminated one against another via an insulation layer placed between them; a spiral axis of the spiral strip of conductor is parallel with a plane of the electrode layer composing the capacitor; and, the electrode layers and the spiral strip of conductor are electrically connected.

A method of the present invention for manufacturing a composite component comprises:

(1) forming a capacitor comprising at least one insulation layer and at least two electrode layers;

(2) forming an additional insulation layer on an external peripheral surface of the insulation layer and the capacitor; and,

(3) forming a spiral strip of conductor and a terminal on an external periphery of the capacitor covered by the additional insulation layer.

Another method of the present invention for manufacturing a composite component comprises:

(1) forming a capacitor comprising at least one insulation layer and at least two electrode layers provided on a portion of the insulation layer;

(2) forming an additional insulation layer on an external peripheral surface of the insulation layer and the capacitor; and,

(3) forming a spiral strip of conductor and a terminal on an external periphery of the additional insulation layer.

Still another method of the present invention for manufacturing a composite component comprises:

(1) forming a capacitor comprising at least one insulation layer and at least two electrode layers;

(2) forming a spiral strip of conductor in close contact to an external periphery of an insulation body or a magnetic body; and,

(3) laminating the capacitor and the insulation body or the magnetic body, on which the spiral strip of conductor is closely formed, via another insulation layer placed between them.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a typical external perspective view illustrating a composite component of a first exemplary embodiment of the present invention;

Fig. 2 is a schematic view illustrating a conceptional structure of the composite component of the first exemplary embodiment of the present invention;

Fig. 3 is a typical external perspective view illustrating another composite component of the first exemplary embodiment of the present invention;

Figs. 4A and 4B are conceptional plan views illustrating other electrode patterns of a capacitor of the first exemplary embodiment of the present invention;

Figs. 5A and 5B are conceptional plan views illustrating still other electrode patterns of a capacitor of the first exemplary embodiment of the present invention;

Fig. 6 is a typical external perspective view illustrating still another composite component of the first exemplary embodiment of the present invention;

Fig. 7 is a schematic view illustrating a conceptional structure of a composite component of a second exemplary embodiment of the present invention;

Fig. 8 is a typical external perspective view illustrating the composite component of the second exemplary embodiment of the present invention;

Fig. 9 is a schematic view illustrating a conceptional structure of another composite component of the second exemplary embodiment of the present invention;

Fig. 10 is a schematic view illustrating a conceptional structure of still another composite component of the second exemplary embodiment of the present invention;

Fig. 11 is a schematic view illustrating a conceptional structure of a composite component of a third exemplary embodiment of the present invention;

Fig. 12 is a typical external perspective view illustrating the composite component of the third exemplary embodiment of the present invention;

Fig. 13 is a schematic view illustrating a conceptional structure of another composite component of the third exemplary embodiment of the present invention;

Fig. 14 is a schematic view illustrating a conceptional structure of still another composite component of the third exemplary embodiment of the present invention; and

Fig. 15 is a schematic view illustrating a conceptional structure of yet another composite component of the third exemplary embodiment of the present invention.



## THE BEST MODE FOR CARRYING OUT THE INVENTION

Exemplary embodiments of the present invention will be described hereinafter by referring to the accompanying figures.

5

## FIRST EXEMPLARY EMBODIMENT

Fig. 1 illustrates an example of a schematic external appearance of a composite component of a first exemplary embodiment of the present invention. In particular, the composite component shown in Fig. 1 comprises a coil constructed of spiral conductor 2 adhering closely to a surface of a composite component 1.

A difference between the composite component of this invention and a composite component of the prior art constructed of a coated copper wire wound around a chip capacitor is that the spiral conductor 2 adheres closely to a substrate, since it is formed in a process of manufacturing the composite component.

Also, another difference of the composite component of this invention from a printed and laminated composite component of the prior art composed of a laminated coil and a laminated capacitor is that a spiral axis of the spiral conductor 2 is arranged to be parallel with "a plane of an electrode of a capacitor" or a flat surface of the electrode, so long as the axis of the coil is perpendicular to the flat surface comprising the electrode. This structure provides a superior characteristic for the coil that constitutes the composite component of this invention.

Furthermore, the composite component is provided on its side surfaces with a pair of terminals 3 and 3', which are formed at the same time with the spiral conductor 2, and are

connected to the spiral conductor 2. The composite component internally contains a capacitor constructed of at least two electrode layers and at least one dielectric layer. The composite component may comprise an insulation layer formed on each of the upper and lower surfaces of the capacitor, when necessary.

In other words, Fig. 1 shows a composite component having a filter circuit in which a coil and a capacitor are connected in parallel.

Fig. 2 illustrates an interior structure of the composite component 1 shown in Fig. 1. The composite component 1 is constructed of a laminated structure comprising a capacitor composed of a dielectric layer 4 and a pair of electrode layers 5 and 5', and insulation layers 6 formed on an exterior of the capacitor and serving as a substratum of coil. The electrode layers 5 and 5' include their respective electrode portions, which are exposed at two opposite surfaces of the composite component. Incidentally, although Fig. 2 shows a plurality of the insulation layers 6, the plurality of them is unnecessary. However, at least one of the insulation layers is necessary as an outermost layer, in order to ensure isolation between the electrode layers 5 and 5' and the conductor 2 composing the coil.

It is generally useful to provide a plurality of the insulation layers 6 for a purpose of varying characteristics or improving performance of the coil constructed on an exterior surface of the composite component 1, besides ensuring the isolation between the coil and the electrode layers 5 and 5' of the capacitor. In other words, use of magnetic material and/or non-magnetic material for the

insulation layers 6 can vary the characteristics of the coil such as increasing an impedance thereof.

The dielectric layer 4 constituting the capacitor can be made of any material selected among insulation material and dielectric material according to a desirable performance of the composite component. Also, if the insulation layers 6 is formed of same material as one used for the dielectric layer 4, an entire body of the composite component 1 can be made of a single material. This makes it easier to manufacture the composite component 1, as it eliminates the defects such as delamination, warpage, and the like during sintering of the composite component.

Accordingly, the foregoing structure of this invention provides a manufacturing of thin composite components of superior characteristic.

Fig. 3 illustrates an external shape of the composite component of Fig. 1, of which a surface other than the portions occupied by the terminals 3 and 3' is covered with an external insulation layer 7. The external insulation layer 7 is not always needed, as it depends on use application of the compound component. However, the external insulation layer 7 is necessary in order to ensure sufficient insulation of the coil, or when a change in characteristic of the coil is intended. If magnetic substance is mixed in material of the external insulation layer 7, for example, the external insulation layer 7 reduces leakage flux of the coil and may be used to adjust an electrical characteristic of the coil.

Besides, strength of the composite component can be improved by mixing ceramic materials into the external insulation layer 7, so as to protect the composite component from being damaged or becoming defective during mounting of it

on a circuit board by an automated mounting machine. Or, the composite component can be shielded electrically, if it is covered with the conductive external layer 7 instead of insulation material after insulating the coil portion with an insulation material.

What has been described in the preceding paragraphs is a structure of the composite component having a filter circuit in which a coil and a capacitor are connected in parallel. Describing next is a composite component having a filter circuit of other kinds, which is also manufactured with a method of this exemplary embodiment.

Figs. 4A and 4B show schematic patterns of the electrode layers formed on the dielectric layer 4. The electrode layer 5 shown in Fig. 2 is divided into two electrode layers 5 and 5'', and these electrode layers are connected to their respective terminals 3 and 3', as illustrated in Fig. 4A. The structure of this exemplary embodiment, in which the electrode layer 5 is divided into two separate layers 5 and 5'', and connected respectively to the terminals 3 and 3', can provide a composite component having a  $\pi$ -type filter circuit.

Furthermore, a T type filter circuit can be constructed by exposing a leading conductor portion of the electrode layers 5 and 5' at each side orthogonal to the terminals 3 and 3' of the composite component, connecting a midpoint of the conductor 2 to the lead conductor of the electrode layer 5, and providing a terminal 3'' for connecting the lead conductor of the electrode layer 5', as shown in Figs. 5A, 5B and 6.

A method of manufacturing the composite component of this exemplary embodiment and materials used for it will be described hereinafter in more details by referring to Fig. 2.

The method of manufacturing the composite component of this exemplary embodiment comprises a first step of forming a capacitor; a second step of forming insulation layers on upper and lower surfaces of the capacitor; a third step of covering  
 5 the composite component on its whole surface with a conductive layer; and a fourth step of finishing a few terminals and a coil out of the conductive layer formed in the third step.

First, a sheet of dielectric material and a sheet of insulation material are manufactured in order to make the  
 10 dielectric layer 4 and the insulation layer 6 shown in Fig. 2. A number of dielectric sheets and insulation sheets of a predetermined dimensions are cut out of the sheet of dielectric material and the sheet of insulation material, and electrode layers 5 and 5' of a predetermined pattern are  
 15 formed on the dielectric sheets and the insulation sheets.

A capacitor element of single-piece structure is manufactured by laminating (a) an insulation sheet, (b) a second insulation sheet or a dielectric sheet whereon the electrode layer 5' is formed, (c) a dielectric sheet whereon  
 20 the electrode layer 5 is formed, and (d) another insulation sheet, in this order.

Subsequently, a conductive layer is formed on an entire surface of the capacitor element, and terminals 3 and 3' and a coil 2 are constructed by patterning the conductive layer.

25 A composite component of this invention is completed when an exterior insulation layer 7 is formed on the surface area not occupied by the terminals 3 and 3' of the composite component, if required.

Materials to be used for the above process will be  
 30 described hereinafter.

Material of the insulation layer 6 can be either non-magnetic materials or magnetic materials. Some of the non-magnetic materials are usable for the insulation layer 6 which includes organic insulation material such as epoxy resin and glass fiber composite, polyimide resin, and the like, glass material, glass and ceramics composite, and a variety of ceramics. Any material can be used for the insulation layer 6, so long as it has an electrical insulating property. Use of a non-magnetic material for the insulation layer 6 increases a self-resonance frequency of the coil.

Some examples of the magnetic substances usable for the insulation layer 6 include Ni-Zn ferrite, Ni-Zn-Cu ferrite, and the like, which are generally known for having a great magnetic permeability. Use of magnetic material having a great permeability such as those substances for the insulation layer 6 can increase inductance of the coil.

Material of the conductor 2 and the electrode layers 5 and 5' can be of any material so long as it is a good electrical conductor. In consideration of cost, etc. however, copper, silver, silver palladium alloy and the like material are usually desirable.

There are basically two methods of forming the conductor 2 and the terminals 3 and 3'. One of the methods is to form the conductor 2 and the terminals 3 and 3' by patterning, after forming a ground layer consisting of an insulation material over the entire surface of the composite element made of the laminated capacitor and the insulation layers, and a layer of conductive material such as copper. Means for the patterning include a method using a laser for evaporating an unnecessary portion, a method of machine cutting, and an etching method in

which an etching resist is applied on the necessary portion of the conductive layer.

Some of the methods of forming a conductive layer on the entire surface includes a variety of electroless plating methods, a method of dipping into conductive resin, and vacuum plating methods such as sputtering or a CVD method of various kinds. Among the above methods, a combination of the sputtering and the electro-plating is the most efficient way to form a conductive layer.

Other methods of forming the conductor 2 and the terminals 3 and 3' are such that a conductive layer is selectively formed only on a portion of the conductor 2 and exposed portions of the electrode layers 5 and 5' on the surface of the composite element.

Means of forming the conductive layer includes coating of conductive resin and a laser CVD method, for depositing a conductive layer only on portion for the conductor 2 and the terminals 3 and 3'.

In addition, it is also possible to form a conductor of a predetermined pattern on the surface of a composite element using a vacuum plating method such as sputtering and CVD or a wet plating method, after the undesired portions on the surface of composite element are coated with resist.

The terminals 3 and 3' are made of the same material as the conductor 2 in principle. Unlike the conductor 2, however, it is desirable to construct the terminals with a plurality of layers using different material from that of the conductor 2, if they are used as terminals of the composite component. In specific, a desirable structure of the terminals of the composite component of this invention consists of a ground layer made of copper, silver, silver palladium alloy, or the

like material, an intermediate layer formed by nickel plating, and an outer layer made of tin or an alloy thereof. However, this composition is only one example, and other metals or organic material, e.g. conductive resin, and the like can be chosen as a part of the composing materials of the terminals 3 and 3'.

If the terminals 3 and 3' are formed with conductive resin, they need to be additionally overlaid with another layer of metallic substance such as those described in the preceding paragraphs by means of electro-plating or the like method in order to ensure solderability. However, there are cases that the composite components are mounted with conductive resin for a purpose of lead-free manufacturing. If composite components of this invention are used in such cases, the above-described metal plating is unnecessary.

As another example of using composite components of this invention, there are also cases that the composite components are mounted on a ceramic substrate such as alumina or ferrite, on which a wiring pattern is formed in advance, using high-temperature sintering paste. If this is the case, material of the terminals 3 and 3' needs to have a heat resisting property in order to withstand to the sintering temperature.

Dielectric material composed of well-known organic or inorganic material can be used for the dielectric layer 4. Using material having a large dielectric constant as the dielectric layer 4 can increase the capacitance of the capacitor. In addition, the capacitance of the capacitor can be changed by varying a area of the electrode layers 5 and 5', or a thickness of the dielectric layer 4, both of which constitute the capacitor, even if the same dielectric material is used.



Incidentally, a structure shown in Fig. 2 represents a minimum structure necessary for the composite component of the present invention. In other words, a capacitance of the capacitor can be increased by increasing the laminated structure of capacitors, each of which comprises a combination of the dielectric layer 4 and the electrode layers 5 and 5'. In case of making such a structure, electrodes 5, 5', 5'', 5''', etc. are led out alternately to two sides, and they are respectively connected to the terminals 3 and 3'. Moreover, insulation layers 6 composed of magnetic material may be laminated on both upper and lower sides of the capacitor, as has been described, in order to improve an electrical characteristic of the coil.

One of the important electrical characteristics of the L/C composite component for noise reduction, especially T-type and  $\pi$ -type filters, is a cut-off frequency. The cut-off frequency is defined as a frequency at which a fixed value of attenuation is obtained, and it is determined by an inductance of the coil and a capacitance of the capacitor. For the composite component of this invention, as has been obvious from the foregoing, an inductance of the coil and a capacitance of the capacitor can be changed easily. Accordingly, the invention provides an easy manufacturing method of filters having a wide range of cut-off frequencies.

Further, when manufacturing a composite component having a filter circuit, which requires a plurality of capacitors, the composite component of this invention can easily provide the plurality of capacitor elements formed on a surface of a single layer, as shown in Fig. 4. Unlike the conventional laminated composite component, therefore, the composite component of this invention has such advantages that it is

easy to manufacture, and it only requires a few changes such as a change in the printing pattern in order to manufacture L/C filters of many kinds.

Although what has been described is the composite component having a structure of a surface-mount component, in which terminals are formed directly on side surfaces thereof, it can be made into a composite component with pin terminals or lead wire type components with caps instead of the above described terminals.

When the capacitor is composed of ceramic material, a sintering process is necessary in addition to the laminating process. Details of a method of manufacturing a composite component having a capacitor composed of ceramic material will be described hereinafter.

The insulation layer 6 and the dielectric layer 4 may be formed by such method as green-sheet forming, printing, dipping, powder forming, spin-coating, and the like. The electrode layers 5 and 5' are usually formed by a printing method.

Paste or slurry for use in forming each of the foregoing layers is produced by mixing and dispersing powder having a suitable property, sintering aid agent, inorganic binding agent, or binding resin, and plasticizer, dispersant, etc. as needed, into solvent.

A sintering temperature of the capacitor lies within a range of from 800°C to 1300°C. The sintering temperature determines materials that can be used for the conductor. If silver is used for the conductor material, for example, the sintering temperature of the composite component is restricted by an upper limit of approx. 900°C. On the other hands, the composite component can be sintered at 950°C, if silver-

palladium alloy is used for the conductor. If it is necessary to sinter the composite component at even a higher temperature, the conductor material of nickel, palladium, or the like materials must be used. The exemplary embodiments  
 5 will be described more precisely with the following exemplary embodiments.

# FIRST EXEMPLARY EMBODIMENT

## EXAMPLE 1

10 First, dielectric slurry was manufactured by mixing and dispersing in a pot mill, 100g of titanium oxide powder, 8g of butyral resin, 4g of butyl benzyl phthalate, 24g of methyl ethyl ketone, and 24g of butyl acetate.

Next, dielectric green sheets having a thickness of 0.2mm  
 15 were produced by coating the dielectric substance slurry on PET films using a blade coater, followed by drying.

Electrode layers 5 and 5' were produced by screen-printing commercially available silver paste on the dielectric green sheets.

20 The dielectric green sheets 4 and 6 formed thereon with the electrode layers 5 and 5' were laminated together with other dielectric green sheets not bearing electrode layers, as an alternative to the insulation layers 6, as shown in Fig. 2, and they were formed into a single-piece body by a heat-press  
 25 under a condition of 100°C and 500 Kg/cm<sup>2</sup>.

A capacitor element was completed after the single-piece body of dielectric green sheets was sintered at 900°C for 2 hours. The capacitor element was then copper-plated with electroless plating and barrel plating, to form a copper film  
 30 over an entire surface of the capacitor element.

A spiral conductor 2 as shown in Fig. 1 was formed to construct a coil integrated with terminals by irradiation of a laser beam on the copper film formed on the surface of the capacitor element. The composite component of this invention  
5 was completed upon formation of this coil.

The composite component manufactured in the foregoing process showed superior electrical characteristics when it was subjected to a measurement of various electrical characteristics with an impedance analyzer and a network  
10 analyzer.

#### EXAMPLE 2

Another composite component was manufactured with the same process as that described in the first embodiment, except that ferrite green sheets were used as the insulation layers  
15 instead of the dielectric green sheets not formed with electrode layers.

The ferrite green sheets were manufactured by a process described below.

First, ferrite slurry was manufactured by mixing and dispersing in a pot mill, 100g of Ni-Zn-Cu ferrite powder, 8g  
20 of butyral resin, 4g of butyl benzyl phthalate, 24g of methyl ethyl ketone, and 24g of butyl acetate.

Next, ferrite green sheets having a thickness of 0.2mm were produced by coating the ferrite slurry on PET films using a  
25 blade coater, followed by drying.

The composite component manufactured in this experimental embodiment did not exhibit any defects such as delamination, crack, warpage, or the like. The composite component obtained here showed superior electrical characteristics when it was  
30 subjected to a measurement of various electrical

characteristics with an impedance analyzer and a network analyzer.

Furthermore, a surface of the composite component was coated to form an exterior insulation layer 7, as shown in Fig. 3, so that only the terminals 3 and 3' were exposed. Two kinds of material were used for the insulation layer 7, a thermosetting resin, and a mixture of thermosetting resin and ferrite powder. The composite components with surfaces of excellent insulation were obtained with both materials.

### EXAMPLE 3

In the composite component of the second embodiment, the electrode layer 5 to be formed on the dielectric layer 4 was divided into two separate forms, as shown in Fig. 4A, and another electrode layer 5' was altered in shape so that it was connected to a terminal 3'' in a center of the composite component as shown in Fig. 4B. This embodiment provided the composite component having a  $\pi$ -type filter circuit.

### EXAMPLE 4

A composite component was manufactured by the same method as used in the second embodiment, except that the electrode layers 5 and 5' to be formed on the dielectric layers 4 were altered into shapes shown in Figs. 5A and 5B, and a terminal 3'' was added at a center of the composite component as shown in Fig. 6. In the structure of this experimental embodiment, a conductor 2 is electrically connected to a lead portion of the electrode 5 shown in Fig. 5A, and a center terminal 3'' is connected to a lead portion of the electrode 5' shown in Fig. 5B. This resulted in the composite component having a T-type filter circuit.

## SECOND EXEMPLARY EMBODIMENT

A second exemplary embodiment of the present invention will be described next by referring to the accompanying figures.

5 Fig. 7 is a schematic view illustrating a conceptional structure of a composite component of the second exemplary embodiment of this invention. The composite component shown in Fig. 7 comprises coil 8 and capacitor 9, and lead electrodes 11, 11' and 11" for connecting to external  
10 terminals formed at both sides and a center of the composite component. The coil 8 is formed in close contact to an insulation layer 10 in the same manner as that of the first exemplary embodiment. The coil 8 may be covered with insulation material, other than portions of the lead  
15 electrodes 11' and 11", in the same manner as in the case of the first exemplary embodiment.

Also, the capacitor 9 comprises insulation layers 10 and electrode layers 5 and 5' formed thereon. An exterior surface of the electrode layers 5 and 5' may also be covered with  
20 insulation material in like manner as the coil, except for portions occupied by the lead electrodes 11 and 11'.

Both ends of conductor 2, which constitutes coil 8, are connected to lead electrodes 11' and 11", and electrode layers 5 and 5' of capacitor 9 are connected to lead conductors 11  
25 and 11'.

Lead electrodes 11, 11' and 11" are connected respectively to terminals 3, 3' and 3" of the composite component of this exemplary embodiment, which is shown in Fig. 8. In Fig. 8, an entire surface of the composite component except terminals 3,  
30 3' and 3" is covered with exterior insulation layer 7. All materials and processes used for the composite component of

this exemplary embodiment are the same as those of the first exemplary embodiment.

A method of manufacturing conductor 2 for constituting coil 8 and terminals 3, 3', and 3" remains unchanged from that of the first exemplary embodiment. For instance, conductor 2 and terminals 3, 3', and 3" can be constructed by forming a conductive layer on an entire surface of the composite element, in which the internal capacitor and the lead electrodes are produced in advance, and the conductive layer is patterned thereafter. It is desirable that surfaces of terminals 3, 3', and 3" are additionally covered with an intermediate layer of nickel, and an outermost layer of tin or an alloy thereof; both of these layers are made by plating.

Although, a structure shown in Fig. 7 constitutes an L-type filter circuit, the same structure can constitute a T-type filter circuit by drawing out lead conductor 12 from electrode layer 5, and connecting it to a midpoint of conductor 2 composing coil 8, as shown in Fig. 9. Moreover, the structure can also constitute a  $\pi$ -type filter circuit by drawing out lead conductor 12 from electrode layer 5, connecting it to a lead electrode 11', and drawing out another lead electrode 11" from electrode layer 5', as shown in Fig. 10.

As is obvious from the foregoing exemplary embodiment, many kinds of filter circuits can be manufactured by making a slight change in a printing pattern of the electrodes. In the described exemplary embodiment, and in Figs. 7, 9, and 10, although the capacitor and the coil are shown in a side-by-side arrangement, they can be arranged in a fore-and-aft or a stacked orientation.

## THIRD EXEMPLARY EMBODIMENT

Fig. 11 is a schematic view illustrating a schematic structure of a composite component of a third exemplary embodiment of the present invention. The composite component of this exemplary embodiment has a structure wherein coil 8 and capacitor 9 are laminated together. Coil 8 comprises a plurality of insulation layers 6, and conductor 2 formed in close contact to a periphery of insulation layers 6, and capacitor 9 comprises dielectric layers 4 and electrode layers 5 and 5'.

Both ends of conductor 2, composing coil 8, are connected to lead electrodes 11 and 11', and two electrode layers 5 and 5', composing the capacitor, are connected to lead electrodes 11" and 11' respectively.

Lead electrodes 11, 11' and 11" are connected respectively to terminals 3, 3', and 3" of the composite component of this exemplary embodiment, which is shown in Fig. 12. In Fig. 12, an entire surface of the composite component except terminals 3, 3', and 3" may be covered by exterior insulation layer 7.

Although Fig. 11 illustrates a plurality of insulation layers 6, coil 8 can be constructed with a single piece of insulation layer 6 so long as it is rigid and strong enough to withstand a process of forming the coil. All materials, processes and exterior insulation used for the composite component of this exemplary embodiment are the same as those of the first and second exemplary embodiments.

A method of manufacturing conductor 2 for constituting the coil remains unchanged from that of the first exemplary embodiment. That is, a plurality of insulation layers 6 made of magnetic material or insulative material are laminated together, and a coil is formed on a periphery thereof, in the



same manner as the first exemplary embodiment. Manufacture of the composite component is completed thereafter, when the coil is laminated over separately prepared capacitor 9.

A difference between the composite component of this exemplary embodiment and those of the prior art are that this exemplary embodiment allows manufacturing of a large variety of coils and capacitors using the same design rules, and resulting in coils of high  $Q$ . In other words, the coils of this exemplary embodiment differ in direction of magnetic flux by 90 degrees from that of the printed and laminated coils of the prior art. For this reason, a cross-sectional area and a length of the magnetic material used for the coils can be increased easily as compared to the prior art coils, thereby obtaining a high  $Q$ .

While the structure shown in Fig. 11 constitutes an L-type filter circuit, Fig. 13 also shows another filter circuit of L-type. In addition, a T-type filter circuit can be manufactured by drawing out a lead conductor 12 from the electrode layer 5, and connecting it to a midpoint of the conductor 2, as shown in Fig. 14.

Furthermore, a  $\pi$ -type filter circuit can also be manufactured by dividing the electrode layer 5 into two sections, and drawing out lead electrode 11" from electrode layer 5' as shown in Fig. 15.

As is obvious from the foregoing exemplary embodiment, many kinds of the filter circuits can be manufactured by making a slight change in a printing pattern of the electrodes.

The present invention provides a composite component, which is thin in size, superior in performance, and contains a filter circuit of various kinds. The present invention also provides a method of manufacturing the composite component

effectively and easily. Accordingly, the present invention is extremely valuable for the related industry.

## WHAT IS CLAIMED IS:

## 1. A composite component comprising:

a capacitor comprising at least one insulation layer and at least two electrode layers; and

a spiral strip of conductor and a plurality of terminals formed in close contact with an external peripheral surface of said capacitor or an external peripheral surface of said insulation layer not comprising said capacitor and having no electrodes disposed thereon,

wherein said electrode layers and said spiral strip of conductor are electrically connected to said plurality of terminals.

2. The composite component according to claim 1, wherein said spiral strip of conductor is constructed of the same material as terminals provided on said composite component.

3. The composite component according to claim 1, wherein a spiral axis of said spiral strip of conductor is parallel with said electrode layers comprising said capacitor.

4. The composite component according to claim 1, containing therein a plurality of capacitors.

5. The composite component according to claim 1, wherein said spiral strip of conductor is electrically connected at two ends and at other portions thereof with said plurality of terminals.

6. The composite component according to claim 1, wherein said spiral strip of conductor and at least one of said electrode layers comprising said capacitor are electrically connected to one of said terminals.

7. The composite component according to claim 1, wherein an entire surface thereof other than portions occupied by said terminals is covered by an external insulation layer.

8. The composite component according to claim 7, wherein said external insulation layer contains magnetic material powder and/or ceramic powder.

9. The composite component according to claim 7, wherein said external insulation layer is covered with conductive material.

10. A composite component comprising:

a spiral strip of conductor formed in close contact with an insulating body or a magnetic body; and

a capacitor comprised of at least one insulation layer and at least two electrode layers,

wherein said spiral strip of conductor and said capacitor are laminated one after another with an insulation layer placed therebetween, a spiral axis of said spiral strip of conductor is parallel with said electrode layers comprising said capacitor, and said electrode layers and said spiral strip of conductor are electrically connected.

11. A method of manufacturing a composite component comprising:

forming a capacitor comprising at least one insulation layer and at least two electrode layers;

forming an additional insulation layer on an external peripheral surface of said insulation layer and said capacitor; and

forming a spiral strip of conductor and a terminal on an external periphery of said capacitor covered with said additional insulation layer.

12. The method of manufacturing a composite component according to claim 11, wherein forming said conductor and said terminal comprises:

forming a conductive layer on the external periphery of said capacitor covered with said additional insulation layer, and

laser machining said conductive layer.

13. The method of manufacturing a composite component according to claim 11, wherein forming said conductor and said terminal comprises:

forming a conductive layer on the external periphery of said capacitor covered with said additional insulation layer, and

machine-cutting said conductive layer.

14. The method of manufacturing a composite component according to claim 11, wherein forming said conductor and said terminal comprises:

forming a conductive layer on the external periphery of said capacitor covered with said additional insulation layer, and

wet-etching said conductive layer.

15. The method of manufacturing a composite component according to claim 11, wherein forming said conductor and said terminal comprises:

covering with a mask a surface portion other than surface areas where said terminals and said spiral strip of conductor are formed on the peripheral surface of said capacitor covered with said additional insulation layer, and

forming a conductor on said surface areas not covered by said mask.

16. The method of manufacturing a composite component according to claim 15, wherein forming a conductor is carried out by vacuum-plating or wet-plating.

17. The method of manufacturing a composite component according to claim 11, wherein forming said conductor and said terminal comprises:

forming a conductor with conductive paste on surface areas where said terminals and said spiral strip of conductor are formed on the external periphery of said capacitor covered with said additional insulation layer, and

forming a plated layer on the conductor formed by said conductive paste.

18. A method of manufacturing a composite component comprising:

forming a capacitor comprising at least one insulation layer and at least two electrode layers provided on a portion of said insulation layer;

forming an additional insulation layer on an external peripheral surface of said insulation layer and said capacitor; and

forming a spiral strip of conductor and a terminal on an external periphery of said additional insulation layer.

19. A method of manufacturing a composite component comprising:

forming a capacitor comprising at least one insulation layer and at least two electrode layers;

forming a spiral strip of conductor in close contact with an external periphery of an insulation body or a magnetic body; and

laminating said capacitor and said insulation body or said magnetic body, on which said spiral strip of conductor is closely formed, via another insulation layer placed therebetween.

## ABSTRACT

A composite component of the invention comprises a spiral strip of conductor and a plurality of terminals formed in close contact to an external periphery of a capacitor constructed of an insulation layer and electrode layers. The spiral strip of conductor is made of the same material as the terminals of the composite component. The composite component is characterized by its structure, namely, a spiral axis of the spiral strip of conductor is parallel with the electrode layers composing the capacitor. Also, the composite component of this invention is able to contain therein a plurality of the capacitors. Therefore, the composite component exhibits superior electrical characteristics not available from similar composite component of the prior art. Furthermore, a method of the invention is capable of manufacturing composite components containing a large variety of filter circuits without requiring a substantial change in the manufacturing condition. The method is therefore suitable for manufacturing the composite components of small quantity, but in numerous variations.



FIG. 1

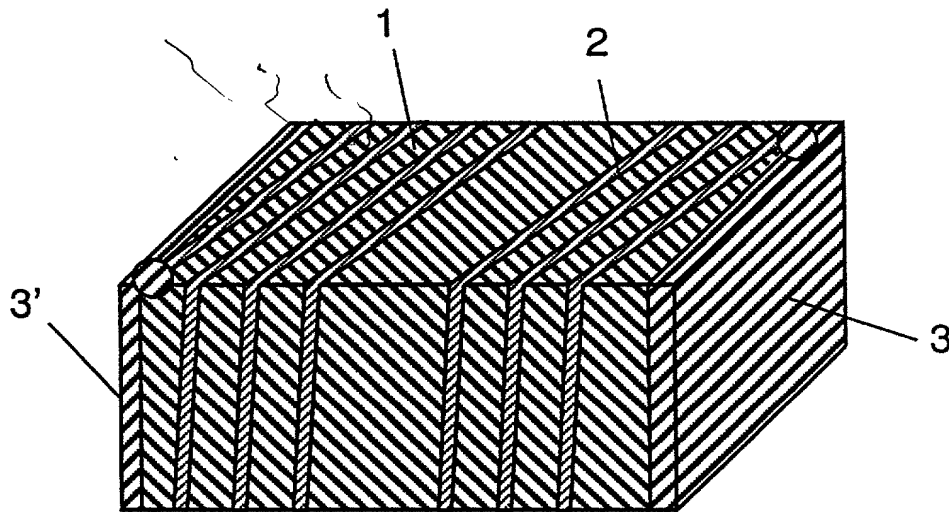


FIG. 2

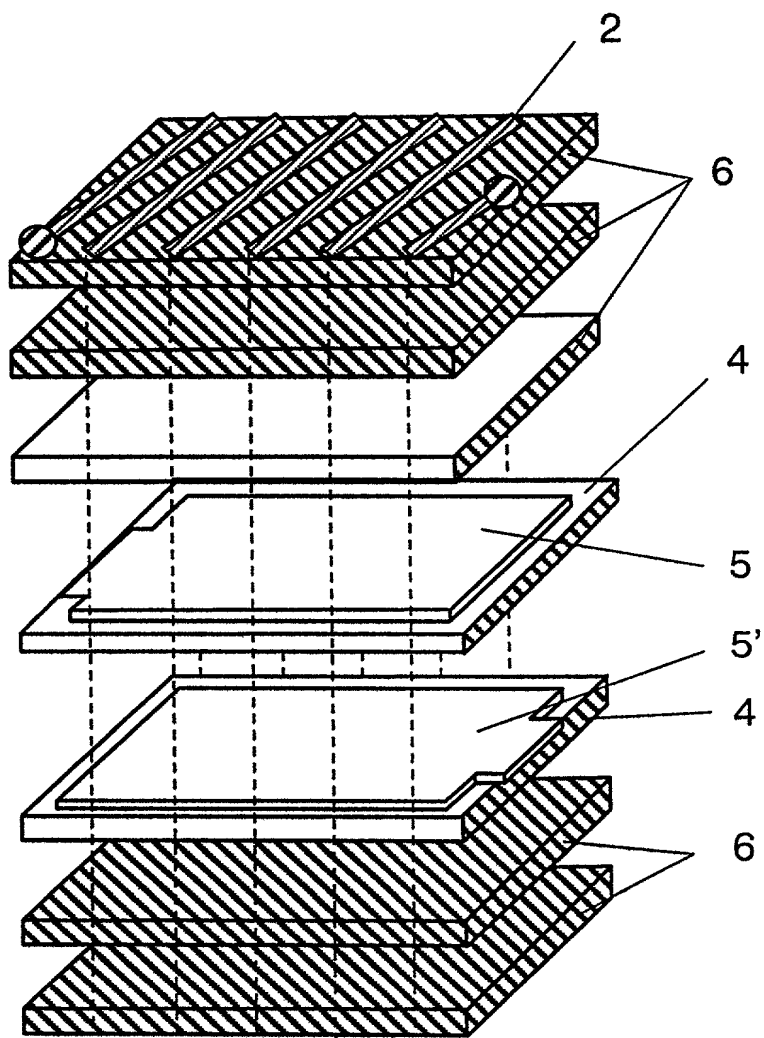


FIG. 3

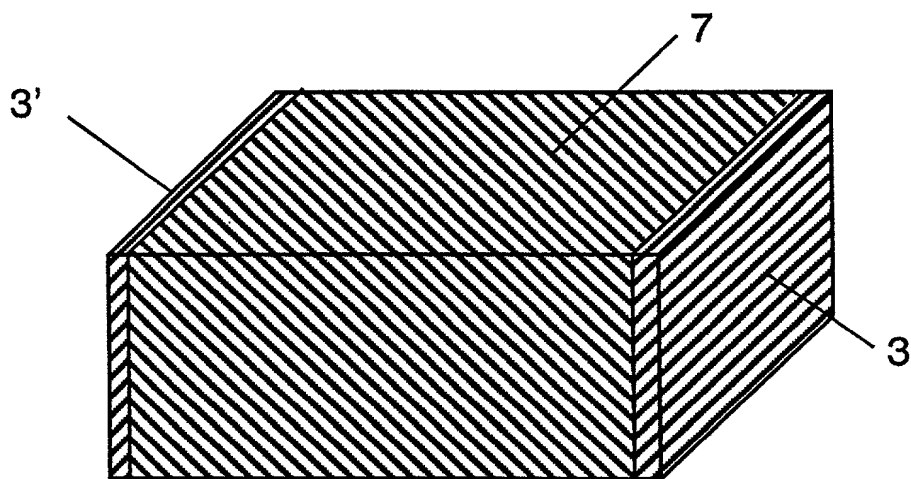


FIG. 4A

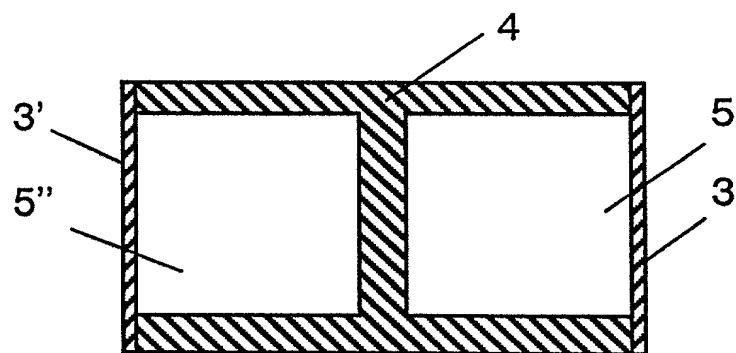


FIG. 4B

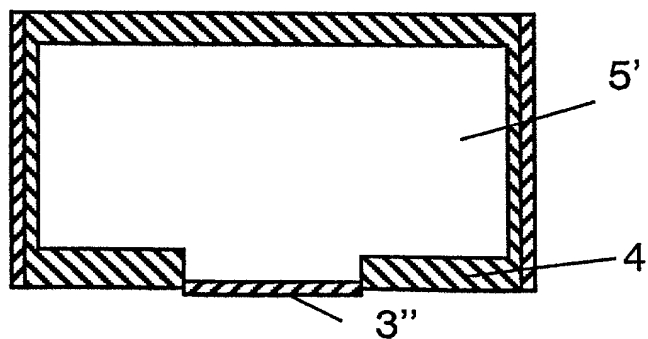


FIG. 5A

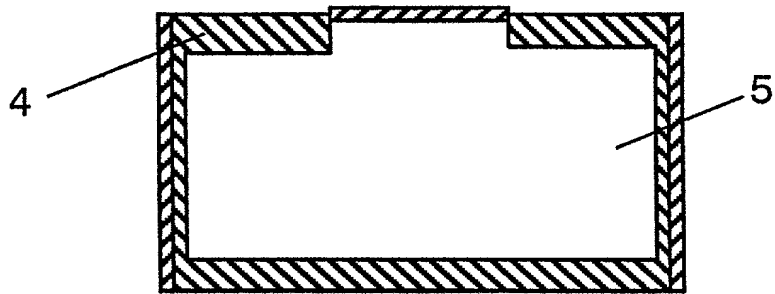


FIG. 5B

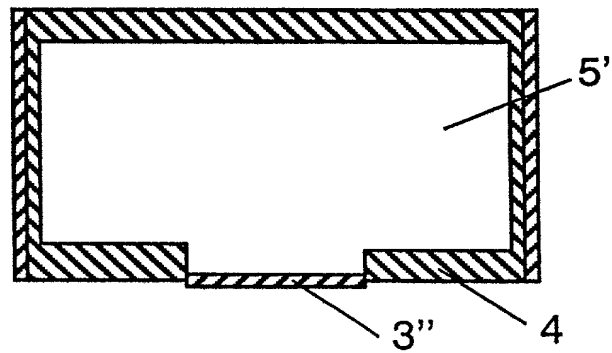


FIG. 6

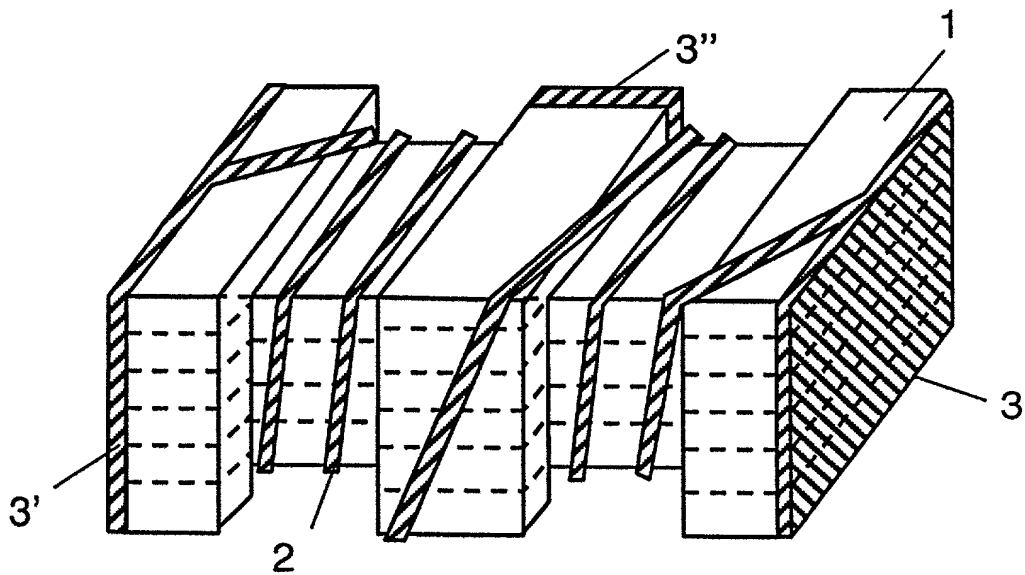


FIG. 7

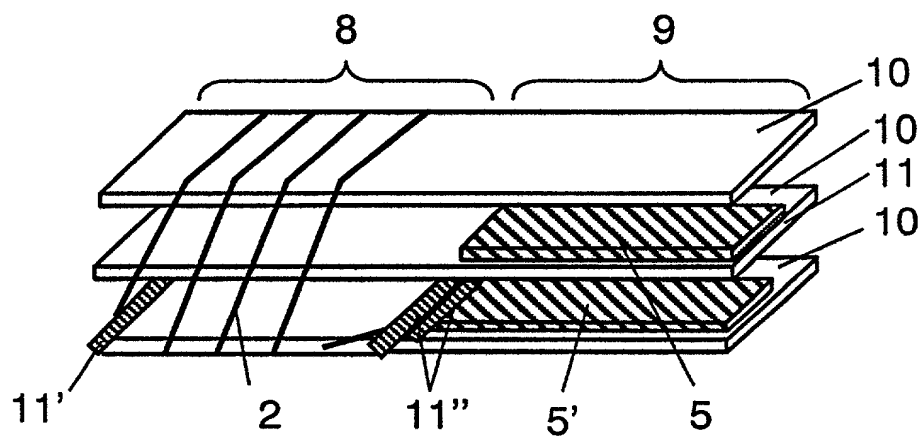


FIG. 8

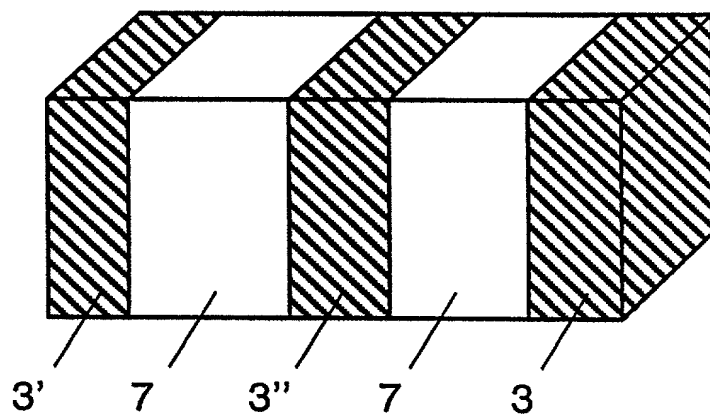


FIG. 9

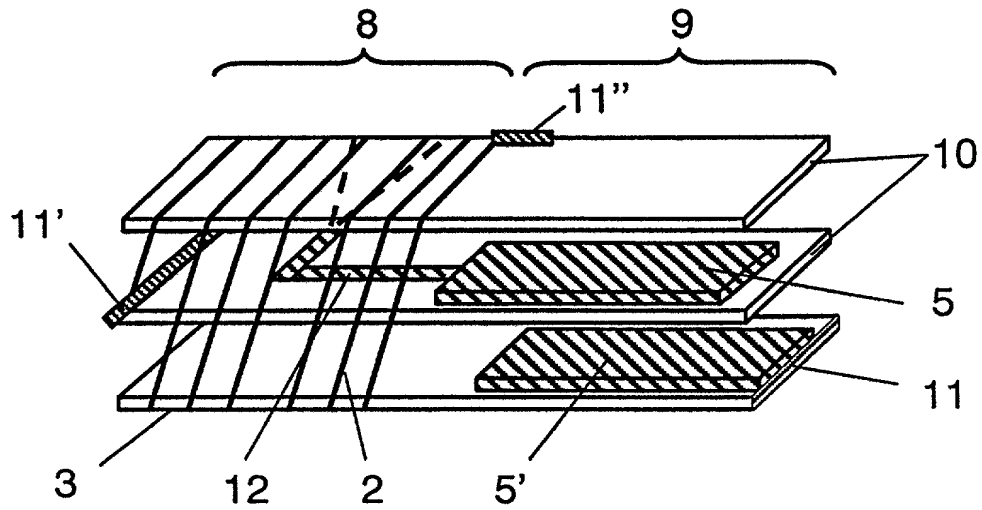


FIG. 10

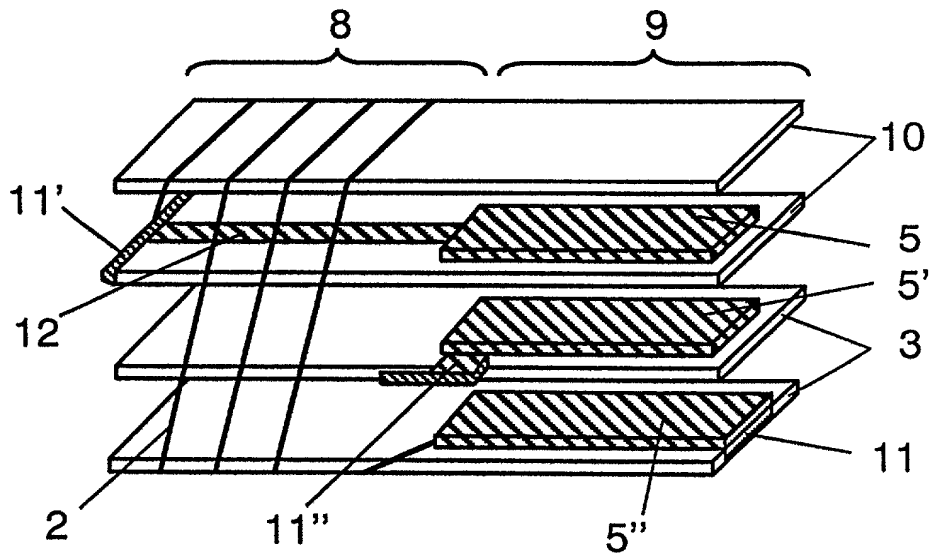


FIG. 11

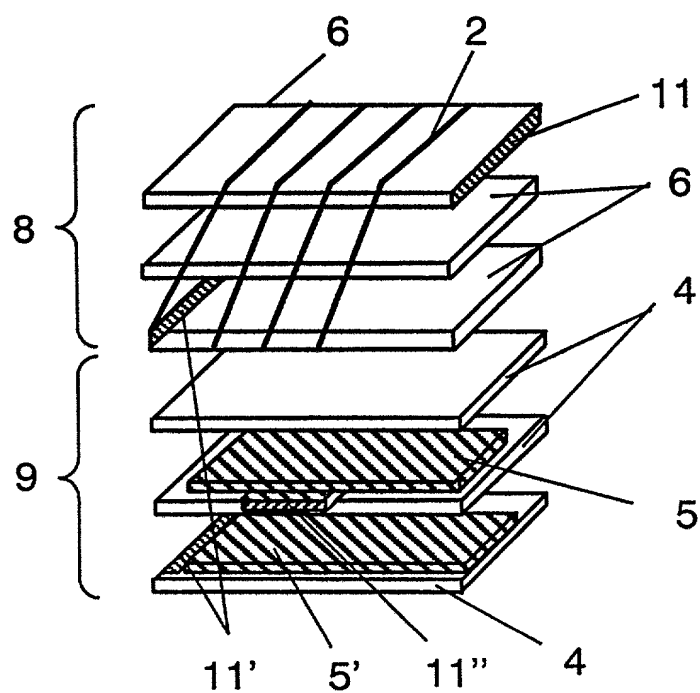


FIG. 12

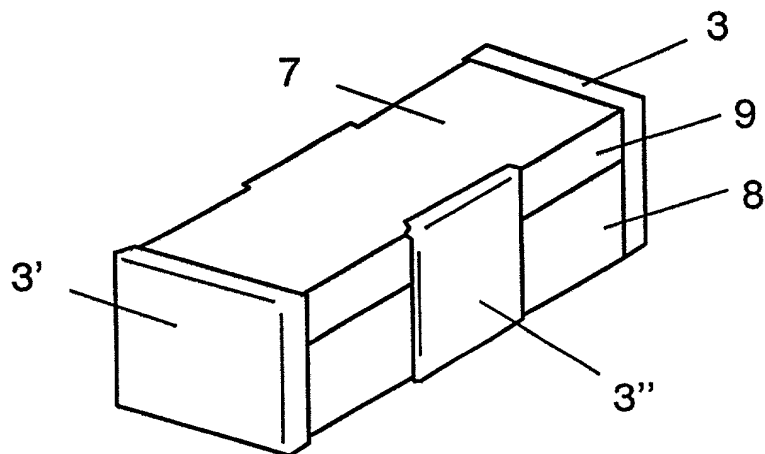


FIG. 13

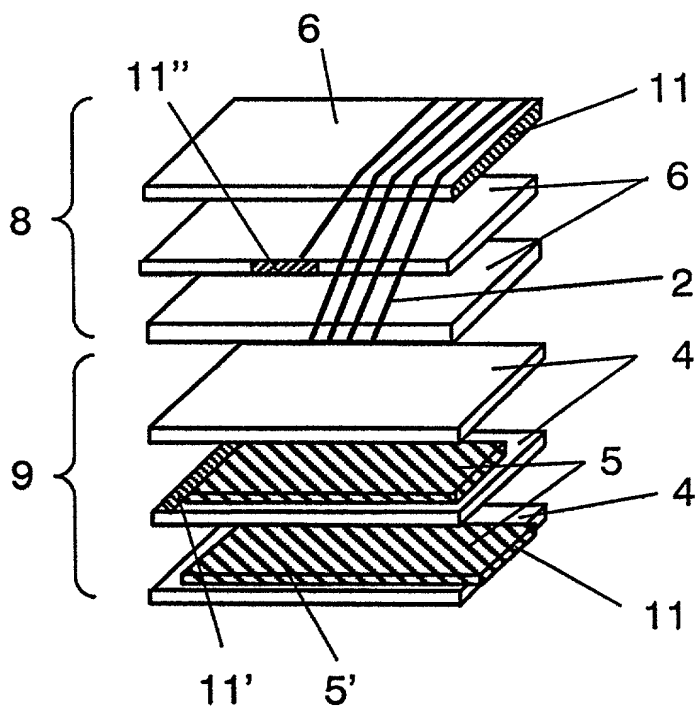




FIG. 14

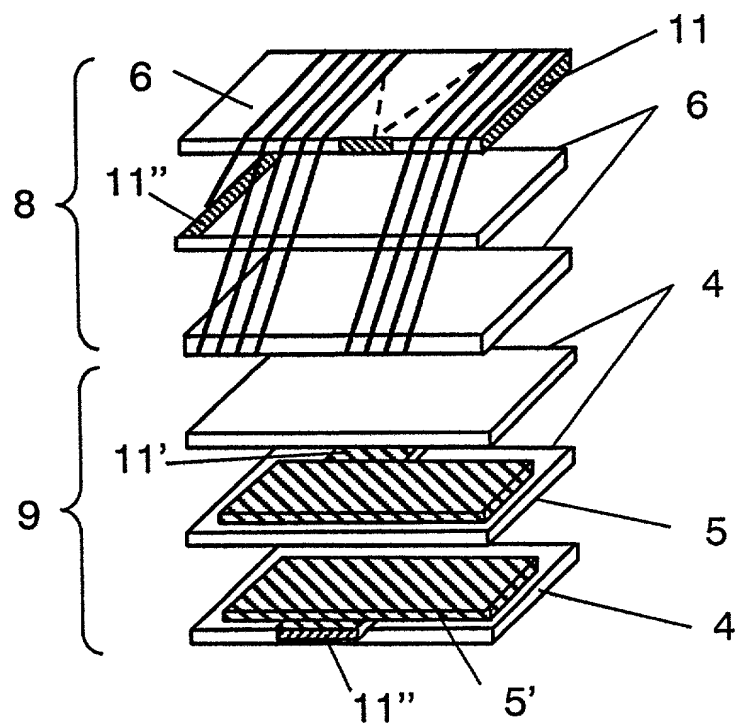
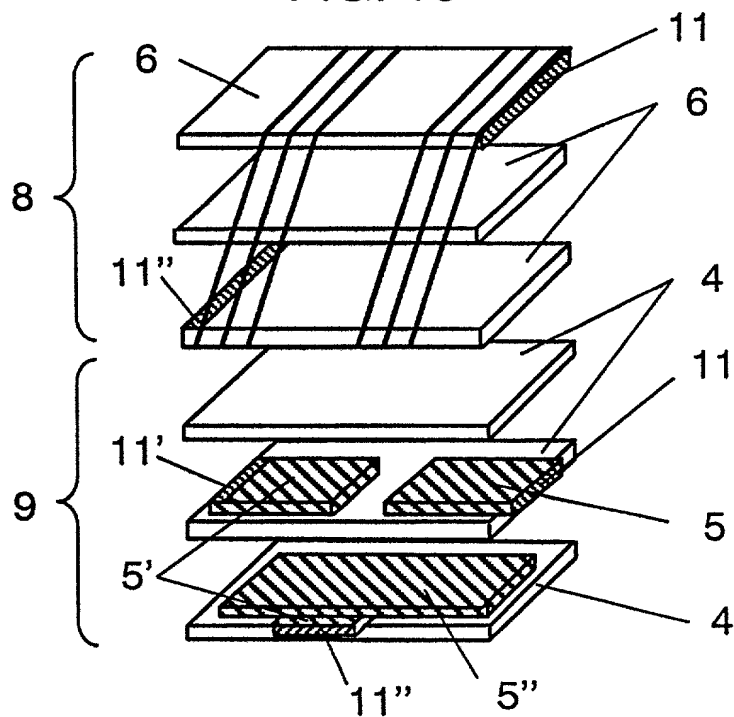


FIG. 15



APPLICATION FOR UNITED STATES PATENT  
Declaration and Power of Attorney

# 3 P 20290

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; that

I verily believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: 1  
COMPOSITE COMPONENT AND METHOD OF MANUFACTURING THE SAME

described and claimed in the specification:

Check one

- \*a. ☐ attached hereto. 09/423,806  
b. ☒ filed on November 12, 1999 as Application Serial No. \_\_\_\_\_ and amended on N/A;  
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information of which I am aware which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a). Under Title 35 U.S. Code § 119, the priority benefits of the following foreign application(s) filed within one year prior to this application are hereby claimed:

Japanese Patent Application No. 10-62804 filed March 13, 1998,  
Japanese Patent Application No. 11-30943 filed February 9, 1999,  
Japanese Patent Application No. 11-36678 filed February 16, 1999, and  
Japanese Patent Application No. 11-36679 filed February 16, 1999.

The following applications for patent or inventor's certificate on this invention were filed in countries foreign to the United States of America either (a) more than one year prior to this application, or (b) before the filing date of the above-named foreign priority application(s):

2 If there are no corresponding applications,  
insert "NONE".

I hereby appoint the following as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent Office:

Roger W. Parkhurst, Reg. No. 25,177; and/or Charles A. Wendel, Reg. No. 24,453.

**ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO  
PARKHURST & WENDEL, L.L.P., 1421 Prince Street, Suite 210, Alexandria, Virginia 22314-2805 Telephone:  
(703) 739-0220.**

I hereby declare that I have reviewed and understand the contents of this Declaration, and that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Ibata

5 Date of Signature

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Month

Day

Year

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\*\*Note to the Inventor. Please sign name on line 4 exactly as it appears in line 3 and insert the actual date of signing on line 5.

**IF THERE IS MORE THAN ONE INVENTOR USE PAGE 2 AND PLACE AN "X" HERE**

# PAGE 2 OF U.S.A. DECLARATION FORM

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Day

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address, including country)

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5 Date of Signature

Month

Day

Year

6 Residence

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Country

7 Citizenship

8 Post Office Address

(Insert complete mailing  
address, including country)

\*Note to Inventors: Please sign name on line 4 exactly as it appears in line 3 and insert the actual date of signing on line 5.

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